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BREEDING AREAS AND ECONOMIC DISTRIBUTION OF THE BEET LEAFHOPPER IN NEW MEXICO, SOUTHERN COLORADO, AND WESTERN TEXAS

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INTRODUCTION

The beet leafhopper (*Eutettix tenellus* (Bak.)) was found to infest beets, beans, tomatoes, and other truck crops, as well as wild plants, east of the Continental Divide in New Mexico and southern Colorado, and in western Texas, during the period 1928–34. The source of this infestation was traced through field surveys, which indicated the relative abundance and distribution of the leafhopper, and through studies on curly top infection in experimental and commercial sugar-beet fields. Collections taken from Russian-thistle (*Salsola pestifer* A. Nels.) in New Mexico during the summers of 1928 and 1929 showed that the leafhopper populations increased toward the southern part of the State. Curly top disease on various crops also showed an increase southward. These data led to the discovery of extensive stands of a perennial mustard, *Lepidium alyssoides* A. Gray, which were found to be the principal breeding source from which the infested areas in New Mexico, southern Colorado, and western Texas received influxes of the beet leafhopper during May and June.

Extensive field surveys were made throughout New Mexico, southern Colorado, and western Texas during the summers of 1928 and 1929, and less extensive surveys were continued in these sections during 1930 and 1931. Ecological investigations were made in the permanent breeding grounds from October 1929 to October 1931, sup-

[1] The writer acknowledges his indebtedness to Walter Carter and P. N. Annand for their helpful direction of the work over which they had charge during the early and later parts, respectively, of the period in which the studies were made; to W. C. Cook and M. F. Bowen for assistance in the preparation of the manuscript; and to R. F. Crawford and J. R. Eyer of State College, N. Mex., for aid extended during the progress of these studies.

plemented by observations in March 1932, 1933, and 1934 to determine leafhopper abundance and host conditions.

Prior to the investigations reported in this circular the location and extent of the breeding areas of the beet leafhopper east of the Continental Divide were not known, but the occurrence of the insect at several points in sufficient numbers to be of economic importance had been ascertained. Crawford (*5*) [2] found chili peppers affected by curly top in New Mexico. Overpeck (*6*) showed that curly top was a limiting factor in commercial sugar-beet production at State College, N. Mex. Carter and Crawford (*4*) showed that a strain of tobacco at Albuquerque was seriously affected by curly top. Ball (*3*) recorded the disease at Amarillo, Tex.

SURVEY METHODS

The net method was used during summer surveys of 1928 and 1929 to ascertain the relative abundance and distribution of the beet leafhopper. One sample of 50 sweeps of the collecting net was taken at the same time each season from each of 454 environments well scattered over native and cultivated districts of southern Colorado, New Mexico, and western Texas.

Leafhopper abundance in the breeding areas was determined by the net method in conjunction with a cylinder method. Four 50-sweep samples and four to six cylinder samples were taken twice each month at seven widely separated stations. These regular surveys were supplemented by special net surveys to check abundance more extensively in the breeding grounds and in the infested areas farther north.

The cylinder method was similar in principle to that briefly described by Shelford (*8, p. 43*) except that no attempt was made to study soil insects, and the size and shape of the cylinder differed. The cylinder covered 0.52 square foot, and the insects confined were killed with calcium cyanide. After the cylinder was removed from the plants, insects were gleaned from the soil surface. With these data as a basis the mean number of leafhoppers per square foot was calculated.

In each cultivated district the mean percentage of beets infected with curly top was established by examining center leaves from 100 to 200 plants from groups of 25 taken at random in 1 to 10 fields.

PERMANENT BREEDING AREAS

LOCATION

Permanent breeding areas of the beet leafhopper in southern New Mexico and western Texas, which produce leafhoppers that move in the spring to infest areas to the north and northeast, were found to coincide mainly with the distribution of a perennial mustard, *Lepidium alyssoides*, as shown in figure 1. In New Mexico these areas were confined to Dona Ana, Otero, and Eddy Counties. More specifically, the mustard occurred in the foothills on both sides of the Mesilla Valley, in the vicinity of the Sunken Mesa, over a large

[2] Italic numbers in parentheses refer to Literature Cited, p. 13.

part of the Tularosa Basin, and in spots along the Pecos River south of Roswell. Very extensive stands were found southward into Texas in El Paso and Hudspeth Counties, and in the southwest portion of Culberson County west of the Guadelupe and Delaware Mountains, to approximately 25 miles southeast of Van Horn. Small patches were

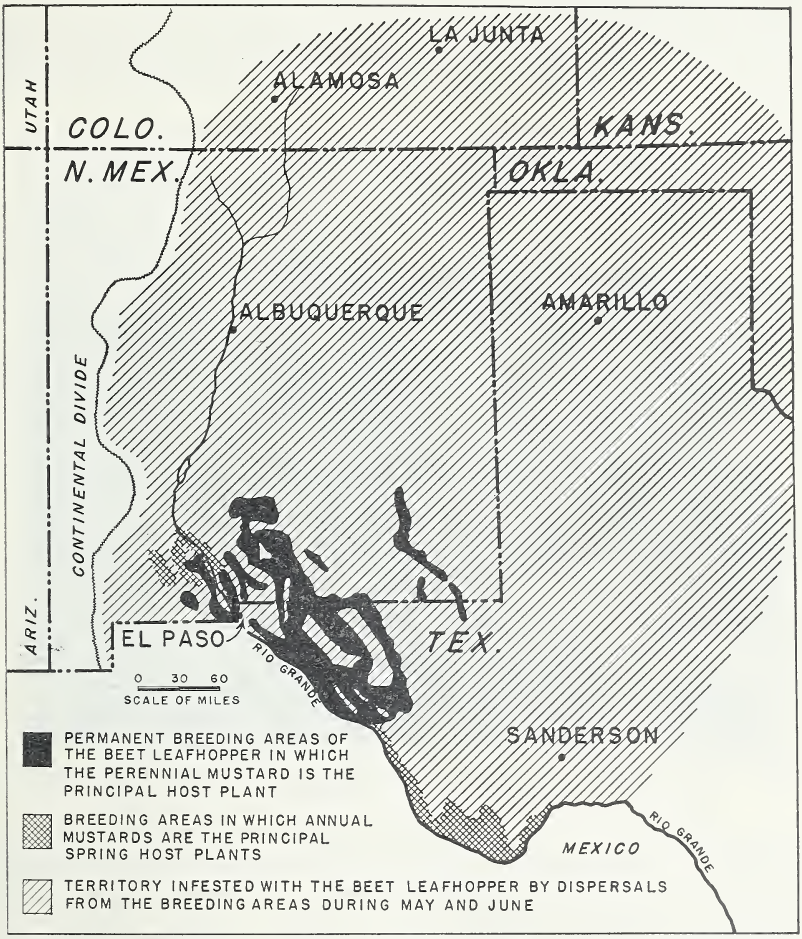

FIGURE 1.—Breeding areas of the beet leafhopper east of the Continental Divide and territory infested by leafhopper flights from the breeding source during May and June.

also found along the Pecos River where it divides the counties of Loving and Reeves. No survey data are available, but it is probable that the mustard extends into Mexico at least along the foothills adjacent to the Rio Grande.

The breeding areas in which annual mustards are the principal spring host plants of the leafhopper (fig. 1) seem to be of only minor importance from the standpoint of spring numbers, and these areas will be discussed later.

HOST CONDITIONS AND DISTRIBUTION

Lepidium alyssoides, the principal host of the beet leafhopper in the permanent breeding areas, begins to resprout at the crown of the plant in September, before the summer growth completely dries, and the seed germinates in October or November when moisture conditions are favorable.

Germinated and resprouted *Lepidium alyssoides* plants as they appeared early in March 1931 in the foothills of the Mesilla Valley are shown in figure 2. The small clumps in the foreground are re-

FIGURE 2.—Germinated and resprouted *Lepidium alyssoides* plants early in March 1931 at Canutillo station, northwest of El Paso, Tex.

sprouted and the very small plants scattered between them are fall-germinated. Other native vegetation characteristic of these mustard environments consists of mesquite (*Prosopis glandulosa* Torr.), creosotebush (*Covillea tridentata* (DC.) Vail), althorn (*Koeberlinia spinosa* Zucc.), small-leafed sumac (*Rhus microphylla* Engelm.), tree yucca (*Yucca elata* Engelm.), a cactus, *Echinocactus wislizeni* Engelm., and bunch grass of the genus *Sporobolus*, although grasses are very sparse. The mustard is apparently a native plant in the association, and since livestock do not browse on it in the green state, it is possible that the plant has become more common under overgrazed conditions, whereas forage grasses have diminished.

Stands of *Lepidium alyssoides* occur normally within the limits of the black areas shown in figure 1, which cover approximately 8,000 square miles. The plant occupies 2,000 to 2,500 square miles, and when its density and distribution are normal it covers from 1

to 60 percent of the soil surface. The abundance of the mustard remained about the same from November 1929 to March 1934. It was reduced greatly by drought during the spring and fall of 1927 and again during the spring and fall of 1934. Weather records show that extreme droughts are rather infrequent in this section, there having been only four of a similar character during the past 36 years, and these were approximately 10 years apart. The time required for the plant to regain its normal abundance ranges from 1 to 3 years, depending on late fall rainfall to cause germination.

The importance of *Lepidium alyssoides* as a host of the beet leafhopper is evident when consideration is given to its extensive distribution, comparative stability, and the number of leafhoppers produced on it. Quantitative cylinder and net samples taken in the mustard areas showed that the plant produced large populations of leafhopper nymphs. Cylinder samples taken at seven stations between May 25 and June 2, 1931, indicate that the mean number of second-brood nymphs per square foot ranged from 13.1 to 77.3. Net samples taken at the same time showed means of 28.5 to 842.5 nymphs per 50 sweeps. It is estimated that *L. alyssoides* produced 90 percent of the spring leafhopper numbers in this area and five other plants 10 percent. *Dithyrea wislizeni Engelm.* and *Cheirinia bakeri* (Greene) Rydb. produced approximately 8 or 9 percent of the leafhoppers and *Sophia halictorum* Ckll., *Lepidium lasiocarpum* Nutt., and *Abronia fragrans* Nutt. 1 to 2 percent.

HOST SEQUENCE IN THE LEPIDIUM AREAS

During 1930 and 1931 *Lepidium alyssoides* was the only summer and fall host over about 80 percent of the territory covered by the *Lepidium* areas. This mustard remained green throughout both years, and the leafhopper continued to reproduce on it during the normal breeding period. Early in August 1931, when summer and fall hosts were at their prime, cylinder samples from five *L. alyssoides* environments showed means of 13.8, 3.3, 3.8, 3.7, and 1.3 nymphs per square foot of host area. The plants sampled were not intermixed with other summer and fall hosts, but they were in the foothills along the Rio Grande where summer and fall hosts were common.

In the remaining 20 percent of this territory *Lepidium alyssoides* was mixed with other hosts from the last of July to the middle of October in 1930 and 1931. These plants are listed in the order of their importance, on the basis of distribution and the number of leafhopper nymphs found on them, as follows: *Tidestromia languinosa* (Nutt.) Standl., *Acanthochiton wrightii* Torr., *Trianthema portulacastrum* L., *Pectis papposa* Torr., *Salsola pestifer*, and *Amaranthus wrightii* Torr. These plants were found to occur commonly within agricultural districts and along foothills of the Rio Grande beginning at Hatch, N. Mex., and continuing southeastward down the river. *T. languinosa* not only occurred sparsely along foothills of the Rio Grande, but was found in spots on the Deming plain and in the Tularosa Basin in New Mexico. That portion of Texas which is a continuation of the Tularosa Basin also maintained spotted stands of this plant. Observations made in these areas during September

1935 showed that summer host plants of the beet leafhopper were more abundant than they had been in previous years, and along with this condition fall leafhopper populations were very high. In general an increase in the abundance of late summer host plants seems to cause an increase in fall leafhopper populations.

Russian-thistle serves as an important spring host of the beet leafhopper in some breeding areas, but in New Mexico and Texas it germinates early in the spring and is limited to cultivated districts, where the use of irrigation water leads to a rank growth, which invariably sponsors low leafhopper populations. Its very limited distribution within the breeding areas is another factor which places it fifth in importance as a summer and fall host.

AREAS INFESTED BY SPRING FLIGHTS FROM THE MUSTARD AREAS

The beet leafhopper is classed among those insects which disperse by flight each spring from their permanent breeding grounds to infest agricultural districts and wild plants at various distances. Annand (*1*) says: "It is apparently certain that flights in the California area can be measured by 200 or 300 miles." Annand and Davis (*2*) state: "During the spring of 1931 flights of 250 to 300 miles into the central Utah sugar-beet area were made." Severin (*7*) indicates flights of 150 miles in the Sacramento Valley of California.

EVIDENCE AS TO THE SOURCE

To prove that an agricultural district receives its infestations of the beet leafhopper from a distant source is a difficult problem. An attempt will be made in this circular to show a relationship between the New Mexico-Texas breeding area and leafhopper infestations in distant cultivated districts, (1) by movement of adult leafhoppers from the breeding source and their coincident detection at cooperative sweep stations, (2) by host conditions in the breeding grounds as related to curly top infection at Las Vegas, N. Mex., and (3) by showing that curly top decreases, in a general way, as the distance from the breeding source increases. Wind direction during the spring also seems favorable to the movement of leafhoppers toward the north and northeast.

An area 10 miles northwest of El Paso, Tex., known as Canutillo station (fig. 2), was selected in the fall of 1930 for population studies the following spring. The area covered about half an acre and was representative of the entire breeding area. A cylinder sample was taken weekly from each of six different points and they were combined to make a sample of the area. Some of the quantitative data from this station are given in table 1. These data cover the period from May 4, when the first-brood adult population was at its peak, to June 20, after the majority of second-brood adults had left the area. First-brood nymphs were separated from second-brood nymphs on the basis of size, which was possible owing to a break in the presence of first-instar nymphs between the two broods. No second-brood nymphs were present on May 4, but on May 11 the mean number was over 14 per square foot. First-instar nymphs appeared

suddenly in large numbers after they had been scarce for several weeks. The standard errors of the means of the samples are comparatively high because leafhopper numbers varied greatly in the different exposures. They are higher than would occur if the samples were taken from a homogeneous environment. Approximately 20 percent of the host plants died during the period indicated in table 1, which should have caused the insects to concentrate on the remaining plants, but actually a decided decrease is shown in the mean number of adults of each brood from week to week. Between May 4 and 25 there was a decrease of 74.6 percent in the total first-brood population. The peak of second-brood adults, which was three times as large as the first-brood peak on May 4, occurred on June 2. Between June 2 and June 20 there was a decrease of 69.77 percent in the total second-brood population. Samples of 100 sweeps each were taken daily on Russian-thistle from early in April to late in June at Belen and Cuervo, N. Mex., and near La Junta, Colo. An influx of leafhoppers was detected at Belen, 204 miles north, on May 10 and at Cuervo, 250 miles north, on May 18. No leafhoppers were caught 430 miles northeastward at La Junta until June 14, after many second-brood adults had left the breeding areas. Whereas these data in themselves are limited and do not prove the source of the leafhoppers involved, they do indicate that infestations in these agricultural districts occurred coincidentally with leafhopper decreases in a representative portion of the breeding area.

TABLE 1.—*Beet leafhopper adults and nymphs per square foot on Lepidium alyssoides at Canutillo station, Tex., May 4 to June 20, 1931*

Date	Samples	Beet leafhoppers per square foot			
		First-brood adults	First-brood nymphs	Second-brood adults	Second-brood nymphs
	Number	*Number*	*Number*	*Number*	*Number*
May 4	6	10.53±1.61	5.35±0.97	0.00	0.00
May 11	6	6.55±1.28	4.64± .89	.00	14.21±4.71
May 18	16	5.58± .89	2.29± .30	.00	33.43±6.27
May 25	6	4.12± .91	.00	.00	64.16±7.93
June 2 [1]	5	.00	.00	31.85±6.52	54.05±8.88
June 8	6	.00	.00	26.52±8.73	30.56±4.69
June 14	6	.00	.00	11.73±1.95	20.79±5.88
June 20	6	.00	.00	4.23±1.53	21.74±5.63

[1] No doubt a few first-brood adults were present on this date, but most of the adults were of the second brood.

Quantitative studies made in the areas of *Lepidium alyssoides* each spring during the period 1930–34 indicated strongly that the abundance of fall-germinated plants of this species determined to a considerable degree leafhopper numbers, irrespective of the number of resprouted plants present. The significance of fall germination was particularly evident during the spring of 1932 when, according to other factors, leafhopper numbers should have been large, but they were small, for no apparent cause except the lack of germination in approximately 80 percent of the territory. It is not intended to convey the idea that resprouted plants do not serve for spring

breeding of the leafhopper, but rather that the area apparently becomes much more productive of leafhoppers when there is an abundance of fall-germinated plants.

A relationship between the abundance of fall-germinated *Lepidium alyssoides* in the New Mexico-Texas breeding area and curly top infection in sugar beets at Las Vegas, N. Mex., a cultivated district 265 miles north of the center of this breeding area, is shown in table 2. The disease records were made late in September each season. With the exception of 1929 the estimated percentage of the total area with germinated plants coincides in a general way with curly top damage. A possible explanation of the 1929 departure from the general trend is as follows: Survey notes show that *L. alyssoides* occurred over only about 1 percent of its normal range during the summer of 1928, apparently owing to the extreme drought of 1927. Weather records indicate that the mustard could not have increased in distribution by germination to approximately 85 percent of its normal range until late in November 1928. The area was probably not populated to any extent during the winter of 1928–29 because the mustard germinated rather late.

TABLE 2.—*Comparison of the estimated proportion of the Lepidium alyssoides area with germinated plants and the density of germination with the proportion of sugar beets infected with curly top at Las Vegas, N. Mex., during September of each year for the period 1928–34*

Winter of observation	Proportion of area with germinated plants	Density of germination	Mean proportion of beets infected with curly top
	Percent		*Percent*
1927–28	0	None	12.6
1928–29	85	Sparse-medium	14.3
1929–30	100	Medium-thick	80.5
1930–31	100	do	73.0
1931–32	20	Very sparse	[1] .5
1932–33	100	Sparse-medium	68.3
1933–34	10	do	[1] 11.0

[1] Harry A. Elcock, formerly of the Bureau of Plant Industry, furnished the curly top data for 1931–32 and 1933–34.

The mean percentages of spring-planted, nonresistant sugar beets infected with curly top late in September in fields within the general infested area are given in table 3. Records were obtained for 5 years from districts where beets are grown commercially and for 2 years from experimental fields. A sufficient number of leafhoppers seemed to be produced in the permanent breeding areas each spring to infect, by the end of the season, all sugar beets planted in close proximity, as illustrated by the data from the plots at State College, N. Mex. At Las Vegas, Springer, and Maxwell, N. Mex., and in the Colorado areas a fairly consistent relationship between the degree of curly top infection and the distance from the breeding source occurs for the 5-year period. In general the intensity of the infection decreases as the distance from the breeding source increases, and apparently all the cultivated districts in these studies are infested from a common source.

TABLE 3.—*Mean proportion of sugar beets infected with curly top within cultivated districts of southern Colorado, New Mexico, and western Texas*

Cultivated district	Approximate distance [1] from breeding source	Mean proportion of beets infected with curly top [2]				
		1928	1929	1930	1931	1933
	Miles	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
State College, N. Mex	57	100.0	100.0	100.0	100.0	100.0
Hatch, N. Mex	98			99.0		
Socorro, N. Mex	171			95.5	94.5	
Belen, N. Mex	204			99.0	96.0	
Portales, N. Mex	215			96.0	98.0	
Albuquerque, N. Mex	233			99.0	100.0	
Las Vegas, N. Mex	265	12.6	14.3	80.5	73.0	63.8
Plainview, Tex	280			90.6	93.0	
Hereford, Tex	285			94.5	89.5	
Tulia, Tex	300			93.6	97.0	
Springer, N. Mex	315	18.0	6.8	51.5	56.3	29.6
Maxwell, N. Mex	330	9.2	9.5	52.0	55.5	39.6
Alamosa, Colo	385	2.0	5.0	14.3	10.0	6.0
La Junta, Colo	430	.5	.9	7.5	5.5	2.2

[1] Approximate air line distance from a central point in the breeding area about 35 miles east of El Paso, Tex.

[2] Disease records were not made in the fall of 1932 except at State College and Las Vegas, which were 100 and 0.5 percent, respectively.

It appears that the beet leafhopper moves along with winds to infest areas outside the breeding source. In general the storm winds blow principally up the Rio Grande from April to September and down the river from October to March. This would seem to favor the northward movement of leafhoppers produced in the spring and the southeastward movement of those produced late in the summer.

The territory shown by diagonal lines in figure 1 is apparently infested from the breeding grounds discussed. No other permanent breeding areas have been found east of the Continental Divide. Areas west of the Divide in New Mexico and Colorado are infested from another source, according to survey data, but it would be unwise to assume that no leafhoppers cross the Divide. For the 7-year period 1928–34 the intensity of curly top damage to sugar beets east of the Divide coincides with the magnitude of leafhopper populations and host conditions in the perennial mustard areas discussed in this circular.

ZONES OF INFESTATION

It is possible to outline zones representing different degrees of leafhopper infestation when the breeding source remains geographically constant, as it did during the course of this study. The percentage of beets infected and the number of leafhoppers collected within the agricultural districts serve as a basis for grouping the districts into zones. An analysis of weather records from points within the breeding source as related to host-plant condition serves as a basis to approximate the degree of infestation to which an agricultural district will be subjected in a given year. Zones of curly top infection within the territory infested by spring flights of the beet leafhopper from the New Mexico-Texas breeding grounds are shown in figure 3.

The general locations of agricultural districts in figure 3 are indicated by the names of towns. Zone 1 shows the permanent breeding

areas of the beet leafhopper principally within the range of *Lepidium alyssoides* in southern New Mexico and western Texas. Zone 1–A indicates an additional breeding area wherein only preliminary observations have been made, but indications are that this area may be of only minor importance in producing spring leafhoppers. Each

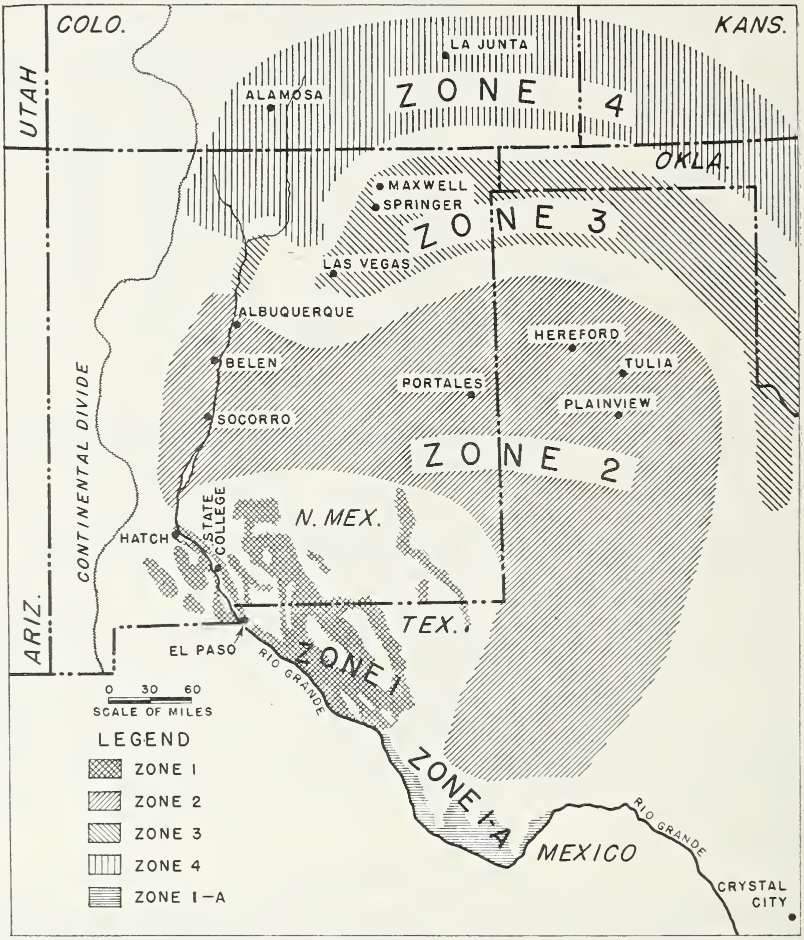

FIGURE 3.—Zones of leafhopper infestation. Zones 1 and 1–A indicate breeding areas of the beet leafhopper. Zones 2, 3, and 4 are infested by influxes from the breeding source in the spring.

spring leafhoppers move northward mainly from zone 1 to zones 2, 3, and 4. Within and adjacent to the breeding areas practically all the spring-planted beets are infected with curly top at the end of each season. Agricultural districts along the Rio Grande from Hatch, N. Mex., southeastward to the limits of the breeding areas in Texas, and all areas south of Tularosa and Roswell, N. Mex., are within zone 1.

On the basis of observations made thus far, it appears probable that 90 to 100 percent of the beets in the districts of zone 2 are subject to curly top infection during approximately half the seasons over a period of several years. Albuquerque, Belen, and Socorro, along the Rio Grande, Estancia Valley, Pecos Valley from Fort Sumner to Roswell, and Tucumcari, Clovis, and Portales, all of which are in New Mexico, belong within zone 2. This zone also includes agricultural districts in Texas near Hereford, Amarillo, Tulia, Plainview, and Muleshoe. Owing to curly top infection, it is probable that, unless curly top-resistant varieties of beets were grown or an efficient control program was instituted, commercial sugar-beet production in these New Mexico and Texas districts would not only prove unprofitable in those seasons during which infection ranged from 90 to 100 percent, but would probably prove unprofitable in other seasons during which infection might occur to a lesser extent.

Zone 3 includes districts where commercial production of nonresistant sugar beets would be rather unprofitable about half the years owing to curly top infection. Within this zone are the agricultural districts near Espanola, Las Vegas, Maxwell, and Clayton, N. Mex.

Zone 4 includes lightly infected districts. Cultivated valleys in the mountainous districts of Chama, Tierra Amarillo, Tres Piedras, Taos, and Mora, N. Mex., belong within this zone. The San Luis and Arkansas Valleys in southern Colorado, as well as small districts near La Veta and Trinidad, are also in zone 4.

Areas between the zones indicated in figure 3 are all infected, but there are no agricultural districts from which information relating to the status of curly top disease might be obtained. How far spring infestations reach into Kansas, Oklahoma, and Texas is not known, but it is probable that any light infestations of leafhoppers in these States would come from the breeding areas shown in figures 1 and 3 in addition to adjacent areas in Mexico.

CROPS INFESTED BY FALL MOVEMENT FROM THE BREEDING SOURCE

The degree of curly top injury to beets grown for seed in the agricultural districts adjacent to the perennial mustard areas seems to be affected by the abundance of the mustard. Severe injury to beets grown for seed as a result of fall movement of the beet leafhopper did not occur in the years 1929 to 1933, inclusive. During this period the mustard stands were maintained throughout their normal range. The abundance of the mustard was very much reduced by a drought during April, May, and June 1934, and this condition was maintained until the fall of 1936. Moderate injury to beets occurred in the fall of 1934 and severe damage resulted in 1935. When the perennial mustard stands are normal in abundance leafhoppers shift onto them when late-summer and fall host plants dry, but when the mustard stands are not present in desert areas the leafhoppers seem to move into cultivated areas, infesting beets, spinach, and other crops severely. Leafhopper numbers in beet fields in the Mesilla Valley, N. Mex., in the fall of 1936 were about one-fifth as large as they were the previous year. Both years host-plant conditions in the summer and fall were favorable for large fall populations of leaf-

hoppers, but in 1936 the perennial mustard germinated in time to provide food for the leafhoppers.

BREEDING AREAS OUTSIDE THE PERENNIAL MUSTARD RANGE

A limited degree of spring breeding of the beet leafhopper normally occurs west of the perennial mustard range. *Sophia halictorum* occurs along foothills on both sides of the Rio Grande between Las Cruces (State College) and Hatch, N. Mex., and it usually serves as a host for the first brood in May before it dries. *Dithyrea wislizeni* occurs during favorable years in two rather extensive areas on the Deming plain west of Las Cruces. The general location of these areas is given in figure 3, and they were studied in conjunction with the *Lepidium* areas.

The beet leafhopper caused severe damage to spinach near Crystal City, Tex., during the fall of 1935. At the request of the Texas Agricultural Experiment Station for assistance in determining the source of the infestation, a survey was made in that portion of Texas during January 1937, and as a result breeding areas were located as indicated by zone 1–A in figure 3. These breeding areas were discovered after the main study had been completed and thus far only preliminary observations have been made in them. The abundance of spring host plants indicates that these areas are capable of producing from one-hundredth to five-hundredths as many leafhoppers in the spring as the perennial mustard areas, although the latter are only about three times as large. The abundance of summer and fall host plants that have dried shows that these areas may be of considerable importance from the standpoint of fall populations of the beet leafhopper, although the observations were made following a season of light infestation in the spinach fields. The data obtained during the survey indicate a possibility that the beet leafhopper moved southeastward with storm winds during the fall into the spinach fields near Crystal City from the breeding areas shown by zones 1 and 1–A in figure 3 and from breeding areas that may occur in Mexico.

SUMMARY AND CONCLUSIONS

Breeding areas of the beet leafhopper (*Eutettix tenellus* (Bak.)) that occur in southern New Mexico and western Texas coincide mainly with the distribution of the perennial mustard (*Lepidium alyssoides* A. Gray). Stands of this plant were found to cover from 1 to 60 percent of the soil surface over 2,000 to 2,500 square miles of a total area of 8,000 square miles. Several other hosts within the perennial mustard range, as well as in other areas to the west and southeast, contribute toward leafhopper numbers, but it is estimated that 85 to 90 percent of the leafhoppers that disperse northward during May and June each season hatch and mature on *L. alyssoides.* Breeding of the leafhopper continues throughout the normal breeding season on the mustard, but numbers resulting from the first two spring broods are of economic concern because most of them disperse to infest distant cultivated crops.

The number of leafhoppers produced by the first two spring broods in the perennial mustard areas seems to vary from year to

year with host conditions. Conditions unfavorable for leafhopper productivity, such as reduced abundance and lack of fall germination of the mustard, seem to cause areas infested by spring flights to receive fewer leafhoppers. These same conditions, however, may cause severe injury to fall and winter crops grown adjacent to the breeding areas when summer annuals such as *Tidestromia languinosa* (Nutt.) Standl., *Acanthochiton wrightii* Torr., and *Pectis papposa* Torr. have been abundant and dry, and when there has been a lack of winter-host germination.

Evidence has been given to indicate that cultivated districts east of the Continental Divide, as far north as the San Luis and Arkansas Valleys of Colorado, receive influxes of the beet leafhopper each spring mainly from breeding areas within the range of *Lepidium alyssoides*. The eastern limits of spring infestations from the same source in Texas, Oklahoma, and Kansas were not definitely established by surveys, but during summer months the insect can probably be found eastward to points where annual precipitation is above 25 inches.

Fall infestations of the beet leafhopper occurred in beets being grown for seed within agricultural districts adjacent to the perennial mustard areas during 1934 and 1935. The fall infestation of 1935 was more severe than that of 1934, apparently because larger numbers of leafhoppers resulted from more favorable summer-host conditions, but the absence of *Lepidium alyssoides* over about 98 percent of its normal range seems to have been the main reason for infestations both years. When the abundance of this mustard was normal, as it was from 1929 to 1933, destructive fall infestations of the beet leafhopper apparently did not occur.

As a result of the surveys and studies made in the New Mexico-Texas breeding areas of the beet leafhopper during the period 1928–36, it seems that a single survey of host conditions and leafhopper numbers in the perennial mustard areas after the first of January could serve as an index of the probable severity of damage in agricultural districts infested by flights the following May and June. The same advance information can apparently be obtained for the severity of infestations in fall crops grown adjacent to the mustard areas by a single survey after the first of August. This applies only to districts infested by spring and fall movements from the perennial mustard areas. Breeding areas with annual hosts are more unstable and such limited observations would be of little value.

Additional breeding areas of the beet leafhopper found during 1937 along foothills of the Rio Grande southeast of the perennial mustard areas seem to be of minor importance from the standpoint of numbers produced in the spring, but they may be of considerable importance in contributing to fall infestations into spinach fields in the vicinity of Crystal City, Tex.

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